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Using Psychomotor Ability for Selecting TOW Gunners

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14. ABSTRACT *(Maximum 200 words)*:

The research examined the incremental validity of a psychomotor tracking test when added to traditional Army measures of cognitive ability. In addition, the actual gunnery performance of 911 TOW Gunners assigned with current procedures from a pool of 10,852 Infantrymen was compared to the predicted performance of 911 TOW Gunners hypothetically assigned on the basis of general cognitive ability (*g*) and tracking ability. Increments in validity resulting from the use of the tracking test were found, although the magnitude of the increases were smaller than expected. However, the increments resulting from hypothetical assignment using the tracking test were substantial. Whether TOW Gunner performance prediction was based on *g*, tracking score, or both, top-down hypothetical assignment of Infantrymen as TOW Gunners resulted in a significant improvement in predicted TOW Gunner gunnery performance and successful completion of training. If assignment as a TOW Gunner was based on tracking ability and was made from the full applicant pool rather than from those first assigned as Infantrymen, it is likely that TOW Gunner performance could be improved with no loss in performance in other military occupations. This is true even if gunnery performance in other Infantry occupations also depends on tracking ability. Implications for classification and job clustering are discussed.

15. SUBJECT TERMS

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FOREWORD

Under Project A, the U.S. Army in the past decade has been developing various measures of ability for potential use in various specialties. Some of these measures target the ability to coordinate fine motor movement with cognitive direction (i.e., psychomotor ability). The psychomotor tracking tests, especially, have been found to strongly predict future gunnery performance of soldiers using weapons systems that require continuous tracking of the target.

This report documents the gains in gunnery performance that can be achieved by using one of these psychomotor tracking tests. In addition, the findings show the gains in gunnery performance are greater than those achieved using the Armed Services Vocational Aptitude Battery (ASVAB) alone. The results clearly show that the use of a specialized psychomotor test can substantially improve the gunnery performance in Infantry occupations using weapons systems that involve direct tracking of the target. Using a psychomotor tracking test in conjunction with the ASVAB in a classification strategy could yield more accurate gunners with no corresponding loss in the performance of soldiers placed in other occupations.

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USING PSYCHOMOTOR ABILITY FOR SELECTING TOW GUNNERS

EXECUTIVE SUMMARY

Research Requirement:

The purpose of the research was to the determine the incremental value of a tracking test in the context of TOW gunnery performance and cognitive ability measures currently in place. An additional objective was to explore whether a case could be made for using the tracking test in a classification framework which would improve gunnery performance with little or no impact on performance in other occupations.

Procedure:

A group of 10,852 Infantry recruits, some of whom had been assigned as TOW Gunners and others who had been assigned to one of three other Infantry occupations, were examined. Incremental validities were computed both before and after adjusting for range restriction. Predictor data were available for all recruits but performance data were available only for those assigned as TOW Gunners. Those with both predictor and TOW Gunner performance data were used to estimate weights to be used in equations to predict TOW Gunner performance. With these equations TOW Gunner performance was estimated for all Infantry recruits, both those who had been assigned as TOW Gunners and those who had not. Using top-down selection based on predicted TOW gunnery performance, Infantry recruits predicted to perform best were assigned as TOW Gunners according to the various equations which either included or excluded the tracking test. The mean gunnery performance of those actually assigned as TOW Gunners was compared to the estimated TOW Gunner performance of those selected using predicted performance. The impact of this hypothetical assignment of TOW Gunners with regard to mean levels of predictor scores for the recruits not assigned as TOW Gunners was computed.

Findings:

The tracking test added .05 validity points and when used to assign Infantry recruits to TOW Gunner positions improved gunnery performance by 0.61 of a standard deviation and successful completion rate for training by 0.41 of a standard deviation. In addition, the cognitive ability of those assigned as TOW Gunners increased by only 0.56 of a standard deviation, in contrast to the 1.76 standard deviations increase when a cognitive ability measure was used to assign the TOW Gunners. This leaves cognitive ability relatively better distributed among the remaining occupations while maximizing the gain in TOW Gunner performance. The earlier in the assignment process that the tracking test is used, the more likely it is that it can be used to

maximize performance in some occupations, and at the same time have little to no impact on performance in other occupations. By holding cognitive ability constant, within the classification process, it should also be possible to improve gunnery performance, although to a lower extent, while having no impact on the current distribution of cognitive ability across occupations.

Utilization of Findings:

The findings clearly make a case for the use of the tracking test within a classification framework at an early point in the Army's selection process. The findings further suggest that improvements in TOW and other gunnery performance (i.e., weapon systems involving direct interaction with the target) could be substantially improved without degrading performance in other occupations. This could not be accomplished with the ASVAB alone.

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INTRODUCTION

Currently there is a debate as to the value and plausibility of differential relevance of various abilities for different occupations. Proponents of general aptitude theory (e.g., Hunter, 1983; Ree & Earles, 1991) have concluded that tests of general cognitive ability are valid and valuable for predicting performance in most if not all jobs, while tests of specific aptitude have little to contribute. Furthermore, Hunter (1983) argued that specific aptitudes are valid only indirectly via their correlation with general cognitive ability.

Cited in support of general aptitude theory is the fact that the observed gains in validity from specific aptitude tests have been small, typically in the range of .01 to .05 (Hunter, 1983; Ree & Earles, 1990; Ree & Earles, 1991; Schmidt, Hunter, & Larson, 1988; Thorndike, 1986; Welsh, Watson, & Ree, 1990). Welsh et al. (1990), for example, found mean increments of .04 to .05 in validity from specific abilities in 118 of 125 military occupations examined in the four services.

In contrast, differential aptitude theory (Schmidt, Hunter, & Larson, 1988; Wernimont & Campbell, 1968) proposes that a test of a specific aptitude, such as a language aptitude test or a psychomotor tracking test, is useful for predicting performance in specific occupations. The reason that specific aptitudes have not contributed more to prediction of performance may be due to the nature of the performance on which the research has been focused. Specific aptitude research has focused on traditional types of occupations which maximizes the likelihood of finding support for general aptitude theory. Jobs which involve learning a new language or firing a psychomotor-demanding weapon system have not been considered. Recently, Silva & White (1993) found that a language aptitude test increased validity over *g* to a larger extent than previously found in other occupational domains. The increase ranged from .01 to .13 validity points depending on whether the focus was on listening, reading, or speaking performance. The current paper will take a further step toward testing the hypothesis that the nature of the job and criterion are important components in determining whether a specific aptitude can be useful for predicting performance. Specifically, it will examine psychomotor tracking ability's incremental (i.e., unique) contribution over general cognitive ability in predicting gunnery performance for TOW Gunners.

The value of specific aptitude tests goes well beyond simple incremental validity. It also can generate utility by matching soldiers and jobs through empirically-based classification (Schmitz, 1988). In contrast to selection where some individuals are rejected outright, placement is concerned with directing those who have already been accepted into jobs most appropriate to their skills (Cronbach and Gleser, 1965). And in practical terms, even a small increase in validity can mean large cost savings for expensive long-term training (Brogden, 1946; White, Nord, Mael, & Young, 1992).

Psychomotor Testing and Current Military Selection

Psychomotor tests measure coordinated motor movements that encompass both cognitive components, such as attention, encoding, and judgment, and motor components such as speed, dexterity, and precision (McHenry & Rose, 1986). More specifically, psychomotor tests generally deal with muscular movements required to precisely adjust or position a machine control mechanism (Peterson, et al., 1990). Psychologists have administered psychomotor tests throughout this century, with much of the conceptual and empirical work done in a military context (Fleishman, 1953; Melton, 1947; Passey & McLaurin, 1966). In an extensive review of the literature, McHenry and Rose (1986) found that psychomotor tests were predictive of training and on-the-job criteria in a wide range of occupations, and that such tests had minimal overlap with measures of general cognitive ability. McHenry and Rose (1986) also advocated using computerized testing apparatus rather than either paper-and-pencil or mechanical apparatus tests for more precise measurement.

Currently, selection into the Army is based primarily on the Armed Services Vocational Aptitude Battery (ASVAB). It is a ten test battery that measures aspects of verbal, mathematical, and technical aptitude and ability, and clerical speed (Schwartz & Mael, 1991). As part of the Army's Project A (Campbell, 1990), in which new selection tests were developed as potential supplements to the ASVAB, two computerized psychomotor tests were developed. These measures have been shown to contribute significantly to the prediction of training performance in a variety of occupations (Busciglio, 1990; Silva, 1989; Busciglio, Silva, and Walker, 1990).

Hypotheses

The following hypotheses are proposed:

First, the tracking test will add incremental value for predicting TOW gunnery performance and successful completion of training. Second, the gains in incremental validity resulting from the use of the tracking test, will substantially improve mean TOW gunnery performance and successful completion of training. Third, use of the tracking test for selection into TOW training will deplete substantially less cognitive ability from recruits available for assignment to other occupations than ASVAB-based composites.

If the above hypotheses receive even moderate support, then the use of the tracking test at an early entry stage into the Army, instead of within the Infantry occupation cluster, should prove highly useful within a classification framework. Even as a classification approach potentially adds substantial value, it is complicated by the requirement to simultaneously consider decision implications for all jobs drawing on the same personnel pool. Thus, assigning soldiers to a specific job based on general desirable attributes could have the undesirable side effect of depleting the talent pool for the remaining jobs. However, when the tests used for placement have differential relevance to the jobs in question, then gains for one job need not deplete the relevant talent pool for other jobs.

METHOD

Incremental validities were computed both before and after adjusting for range restriction in the sample. In addition, a group of Infantry recruits some of which had been assigned as TOW Gunners and others who had been assigned to one of three other Infantry occupations were examined. Predictor data were available for all recruits but performance data were available only for those assigned as TOW Gunners. Those with both predictor and TOW Gunner performance data were used to estimate weights to be used in equations to predict TOW Gunner performance. With these equations TOW Gunner performance was estimated for all Infantry recruits, both those who had been assigned as TOW Gunners and those who had not. Using top-down selection based on predicted TOW gunnery performance, Infantry recruits predicted to perform best were assigned as TOW Gunners. The mean gunnery performance (or mean predicted performance since they are the same) of those actually assigned as TOW Gunners was compared to the estimated TOW Gunner performance of those selected using predicted performance.

Sample

The sample consisted of 10,852 males selected as Infantry recruits based on a minimum Armed Forces Qualification Test (i.e., a composite created from four ASVAB subtests) score and a minimum Combat (i.e., a composite created from four ASVAB subtests) score of 90. The minimum AFQT score represents approximately the 30th percentile normed to the 1980 United States sample of 18-23 year olds (i.e., 1980 Profile of American Youth sample). The minimum score of 90 on the Combat composite represents approximately the 19th percentile normed to the same population. Although a Combat score of 90 is the minimum, most successful recruits in the sample scored well above it. The ASVAB subtests are briefly described in Table 1.

Of the 10,582 recruits, 911 were later actually assigned as TOW Gunners. The remaining 9,941 recruits were actually assigned to one of the three remaining Infantry occupations: Basic Infantryman, Mortarman, and Fighting Vehicle Infantryman. Assignment as a TOW Gunner was not based on an assessment of job-specific aptitudes. Rather, the procedure for actual assignment was based primarily on demand from each of four possible assignment occupations and on keeping recruit quality (i.e., defined on the basis of the Combat score) evenly distributed across the four occupations.

The race distribution of Infantry recruits was 79% White, 15% Black, and the remaining 6% were Asian, American Indian, Hispanic, and other. Compared to Army recruits in other occupations in that time period, Whites are overrepresented (70% is more typical in other occupations) and Blacks are underrepresented (20-25% is more typical in other occupations). Nearly 82% had obtained a high school diploma, 16% had not obtained a high school diploma, and 2% had continued their education beyond high school. Compared to Army recruits in other occupations in that time period, the percentage of non-high school graduates (i.e., 16%) is somewhat higher for this occupation.

Table 1

ASVAB Subtests

ASVAB Subtest[a]	Acronym	Description
Arithmetic Reasoning	AR	A 30-item test of ability to solve arithmetic word problems.
Auto and Shop Information	AS	A 25-item knowledge test of automobiles, shop practices, and use of tools.
Coding Speed	CS	An 84-item speeded test of ability to recognize numbers associated with words from a table.
Electronics Information	EI	A 20-item knowledge test of electronics, radio, and electrical principles and information.
General Science	GS	A 25-item knowledge test of the physical and biological sciences.
Mechanical Comprehension	MC	A 25-item knowledge test of mechanical and physical principles.
Mathematical Knowledge	MK	A 25-item knowledge test of algebra, geometry, fractions, decimals, and exponents.
Numerical Operations	NO	A 50-item speeded test of ability to add, subtract, multiply, and divide one- and two-digit numbers.
Paragraph Comprehension	PC	A 15-item test of reading comprehension.
Word Knowledge	WK	A 35-item vocabulary knowledge test using words embedded in sentences and synonyms.

Note. [a]Scores are standardized to a scale having a mean of 50 and a standard deviation of 10. KR-20 reliabilities for power tests and parallel form reliabilities for speeded tests ranged from .78 to .92 for ASVAB Forms 8, 9, 10 (Kass, Mitchell, Grafton, & Wing, 1983). A Verbal (VE) score is created by combining the scores of Paragraph Comprehension and Word Knowledge.

Measures

g. *g* was a factor score constructed from the weights associated with the first unrotated principal component of the 10 ASVAB subtests. These weights were obtained by executing a principal components analysis of the ASVAB subtests using the 1980 United States sample of 18-23 year olds (Ree & Earles, 1991). In that representative sample *g* was scaled to a mean of 62.20 and a standard deviation of 10. The 10 ASVAB subtests are used operationally for the selection and classification of enlisted military applicants and target verbal, mathematical, and technical aptitude and ability, and clerical speed.

Two-Hand Tracking. This test measures two-hand coordination by recording the distance between a crosshair that is under the examinee's manual control and a target that is being tracked on a computer screen. For each trial, examinees are presented a path consisting entirely of vertical and horizontal lines. At the start of the path is a target box, and centered in the target box is a crosshair. When the trial begins, the target box starts to move at a constant rate of speed along the path. The examinee uses two sliding controls to direct the crosshair along the same path, attempting to maintain the crosshair centered in the box at all times. One sliding control directs the crosshair in a vertical direction, while the other directs it in a horizontal direction. The test consisted of 18 of these trials. Eighteen trials was sufficient to achieve .85 test-retest and .98 split-half reliabilities (Peterson, et al, 1990).

The score for each trial was the average distance of the crosshair from the center of the target box during the trial. In addition, the average distance score across the trials for each examinee was reversed (i.e., higher score indicates higher tracking ability) and converted to a T-score using the mean and standard deviation derived from 33,727 Project A first-tour male soldiers spanning nine occupations. The nine occupations used as a basis for the standardization included non-combat occupations. The purpose of using a standardized score based in part on non-combat occupations such as clerical and medical occupations was to be able to compare Infantry tracking scores to those in a broader range of occupations. Only male soldiers were used for the comparison because all Infantry recruits were male. The Project A and the current sample used recruits at the same stage of selection into the Army.

Training course performance. The gunnery performance of TOW Gunners during training was measured on a high-fidelity TOW gunnery simulator which required the trainee to optically track a moving target (i.e., a target mounted on a moving vehicle) at a distance through an infrared optical device. The target moved only in a horizontal direction at a constant velocity along a paved, reasonably level road. The gunner aligned the crosshair by turning a knob which controlled the weapon horizontally. The target was constantly emitting an infrared signal which was received by the simulator when the crosshair was on the target. The percentage of the time the simulator received the infrared signal was the score for the engagement. The qualifying trials were scored in sets of 10 target engagements. Each engagement was scored for time-on-target on a scale of 0 to 100 (i.e., percentage of time-on-target) and the score for a set was computed by summing the scores for the ten engagements. A score of at least 550 (i.e., 55 percent of time-on-

target) on a set was required to pass training and qualify as a TOW Gunner. Any trainee who did not attain a score of 550 on one of the last 6 sets could not become a TOW Gunner. Since the first two sets were for practice only, a trainee's first opportunity to attain a passing score was actually the third set of engagements. After attaining a passing score on this or a later set, the student's training was complete.

In summary, the two training performance measures of interest in the present research included Gunnery, the trainee's score (an index of time-on-target) on the first qualifying set (i.e., the third set) and Pass, a dichotomous indicator of whether the trainee achieved a passing score on the first qualifying set. By using performance on the first qualifying set as the criterion, one assures an equal amount of experience on the weapon system simulator for all trainees.

Procedure

All Infantrymen in the sample were given the Two-Hand Tracking test along with other psychomotor and spatial measures during in-processing at the Reception Battalion. The ASVAB subtests were administered prior to enlistment. In order to apply the results of this study to the applicant pool prior to selection into the Army, it was necessary to correct the restricted range of the ASVAB subtest scores in the sample using Lawley's (1943) multivariate range restriction method. Using this method, correlations between and within predictor and criterion measures were simultaneously adjusted for explicit (selection on the AFQT and Combat composites) and implicit (selection on the remaining ASVAB components via their relationship with the AFQT and Combat composites) selection on the ASVAB. Lawley's (1943) multivariate method was chosen over multiple univariate adjustments because it is less likely to yield underestimation of the true population correlations (Ree, Carretta, Earles, & Albert, 1994). The analyses were conducted on both the adjusted and unadjusted covariance matrices.

Ordinary Least Squares (OLS) was applied to the correlation matrix corrected for range restriction with the Lawley (1943) method. This yielded estimated indices of correlation and estimated weights to be applied to g and Two-Hand Tracking scores, individually and in combination, to predict TOW gunnery training performance. Indices of correlation based jointly on g and Two-Hand Tracking predictors were adjusted for upward bias using the Stein (1960) correction.

Each of two sets of three performance prediction equations was constructed to predict one of two outcomes: Gunnery performance on the simulator or whether training would be successfully completed. Both sets of prediction equations contained the same predictors and varied only with respect to estimated weights. The three equations were based on the following predictors: 1) g alone, 2) Two-Hand Tracking alone, and 3) g and Two-Hand Tracking jointly.

Following the estimation of these prediction equations the predicted performance of all Infantrymen based on each of these equations was ranked top-down. The 911 Infantrymen predicted to obtain the highest Gunnery scores on the TOW training simulator, according to each

of the three predictor equations for each performance outcome, were identified and assigned as TOW Gunners. Note that assignment was based on predicted Gunnery score and not likelihood of passing training. A sample size of 911 TOW Gunners was chosen to maintain a constant selection ratio across hypothetical placement and actual assignment.

For each performance outcome (i.e., Gunnery and Pass), the mean predicted performance for each set of 911 recruits assigned as TOW Gunners using one of the three prediction equations was compared to the mean performance of those recruits actually assigned as TOW Gunners. In addition, the mean score on *g* and Two-Tracking for those hypothetically assigned as TOW Gunners and those hypothetically assigned to other Infantry occupations were compared.

RESULTS

The means and standard deviations of the criteria and predictors are presented in Table 2 for both Infantrymen actually assigned as TOW Gunners and Infantrymen actually assigned to other Infantry occupations. t-tests were conducted comparing the g, Two-Hand Tracking, Combat, and AFQT composite mean scores of the current sample of 911 TOW Gunners with those of a sample of 9,941 Infantrymen assigned to other Infantry occupations. Since TOW Gunners were selected from the Infantrymen pool, the nonsignificant ($p > .05$) differences in the means across the two samples supports that TOW Gunners were assigned randomly to one of the four possible occupations. Note, however, that Infantrymen as a group, compared to the normative sample (i.e., Project A sample standardized to a mean of 50), scored nearly one-half standard deviation higher on Two-Hand Tracking. To a large extent this may be due to self-selection for an Infantryman position, and also to the moderate relationship between Two-Hand Tracking and Combat scores (both the Infantry and the normative samples had been preselected on the ASVAB and were at the Reception Battalion stage of indoctrination when they were tested on Project A predictor battery).

Table 3 shows the correlations among the predictors and criteria for the sample of 911 TOW Gunners adjusted (below diagonal) and unadjusted (above diagonal) for range restriction on the ASVAB. For the unadjusted correlations, the Two-Hand Tracking was easily the best predictor. The criterion correlations for *g*, Combat, and AFQT were closely clustered but smaller. When the correlations were adjusted for range restriction on the ASVAB all correlations rose and the distinction between the four predictors nearly disappeared, although Two-Hand Tracking still retained a sample-based advantage. The average increase in the predictor-criterion correlations was 70% after adjustment but Two-Hand Tracking, of course, gained the least from the ASVAB restriction adjustment. This accounted for the narrowing of the difference between the adjusted and unadjusted correlations. As expected, the adjusted correlations amongst ASVAB composites were all large (i.e., .85 or greater).

Table 2

Means and Standard Deviations of Predictors and Criteria

	Assigned as TOW Gunners		Other Infantrymen	
Variable	M	SD	M	SD
Criteria				
Gunnery	609.94	123.84	NA	NA
Pass	0.81	0.39	NA	NA
Predictors				
g	66.21	5.36	66.22	5.74
Two-Hand Tracking	54.57	8.70	54.40	8.69
Combat	109.71	11.04	109.70	11.56
AFQT	56.66	19.63	56.95	20.76

Note. N = 911 for those actually "Assigned as TOW Gunners" and N = 9,941 for "Other Infantrymen." TOW gunnery training performance scores not available (NA) hose assigned as "Other Infantrymen."

Table 3

Correlation Matrix of Predictors and Criteria for TOW Gunners

Variable	1	2	3	4	5	6
Criteria						
1 Gunnery	1	.76**	.23**	.31**	.23**	.19**
2 Pass	.77**	1	.15**	.23**	.12**	.13**
Predictors						
3 *g*	.41**	.25**	1	.34**	.87**	.91**
4 Two-Hand Tracking	.43**	.29**	.60**	1	.34**	.31**
5 Combat	.41**	.24**	.95**	.59**	1	.72**
6 AFQT	.37**	.23**	.96**	.56**	.85**	1

Note. N = 911. Correlations above diagonal are based on the actual sample values. Correlations below diagonal were adjusted for range restriction on the ASVAB using the Lawley(1943) multivariate range restriction method. *g*, Combat, and AFQT predictors are autocorrelated to the extent they are constructed from some of the same ASVAB subtests.
** $p < .01$.

The results presented in Tables 4 and 5 indicate that after the Stein adjustment for shrinkage was applied, Two-Hand Tracking when added to *g* incremented the unadjusted multiple R by .10 and .08 for Gunnery and Pass criteria, respectively. When the adjustment for ASVAB range restriction was applied these increments were reduced to .05 for both criteria, but remained statistically significant ($p < .01$). Analyses examining the increment of Two-Hand Tracking when added to Combat, AFQT, and all ASVAB subtests revealed equal, if not larger, multiple R increments. These analyses are not reported in greater detail because of the redundancy of these predictors with *g*.

Impact of Predictor-Based Hypothetical TOW Gunner Assignment

While criterion data existed for only 911 TOW Gunners, predictor data were also available for an additional 9,941 Infantrymen who were assigned to one of the other three Infantry occupations (i.e., Basic Infantryman, Mortarman, and Fighting Vehicle Infantryman). The prediction model equations developed on the 911 TOW Gunners were applied to all Infantrymen to determine predicted TOW Gunner training performance if these Infantrymen had been assigned as TOW Gunners.

Impact of Hypothetical Assignment on TOW Gunner Performance

The 911 Infantrymen hypothetically predicted to be the top TOW gunnery performers were identified by each prediction model. Table 6 presents the hypothetical mean predicted performance on Gunnery and Pass rate on the first qualifying set for the 911 Infantrymen expected to perform best according to each prediction model.

Note that hypothetical assignment as TOW Gunners was on the basis of the expected Gunnery score because it was the primary criterion of interest and could be better predicted. Therefore, the Pass rate may not necessarily always improve along with the mean Gunnery score. However, an unadjusted correlation of .76 between these two criteria insures that improvement in one performance index will be mirrored to a large extent with improvement in the other.

It is clear from Table 6 that the predicted Pass rate improves substantially for those hypothetically assigned as TOW Gunners on the basis of their predicted Gunnery score. Using Two-Hand Tracking scores for hypothetical assignment led to an expected improvement of 0.61 standard deviations in the Gunnery score and a 0.41 standard deviation improvement in the Pass rate when compared to the current method of placing Infantrymen as TOW Gunners. Using *g* for hypothetical assignment of Infantrymen as TOW Gunners led to smaller improvements of 0.44 and .28, for Gunnery score and Pass rate, respectively. Joint use of *g* and Two-Hand Tracking for hypothetical assignment led to smaller performance gains compared to using Two-Hand Tracking alone; a .56 standard deviation improvement in Gunnery performance and a .38 standard deviation improvement in the Pass rate.

Table 4

Predicting TOW Gunnery Performance Using Various Prediction Models

	R		Increment in R from adding Two-Hand Tracking	
Prediction Model	Unadjusted	Adjusted[a]	Unadjusted	Adjusted
Two-Hand Tracking	.31**	.43**		
g	.23**	.41**		
g & Two-Hand Tracking	.33**	.46**	.10**	.05**

Note. Both multiple R estimates involving more than one predictor were adjusted for shrinkage using the Stein (1960) formula.
[a] "Adjusted" and "Unadjusted" columns indicate adjustment or lack of adjustment for range restriction.
** $p < .01$.

Table 5

Predicting Passing TOW Training on First Qualifying Set Using Various Prediction Models

	R		Increment in R from adding Two-Hand Tracking	
Prediction Model	Unadjusted	Adjusted[a]	Unadjusted	Adjusted
Two-Hand Tracking	.23**	.29**		
g	.15**	.25**		
g & Two-Hand Tracking	.23**	.30**	.08**	.05**

Note. Both multiple R estimates involving more than one predictor were adjusted for shrinkage using the Stein (1960) formula.

[a] "Adjusted" and "Unadjusted" columns indicate adjustment or lack of adjustment for range restriction.

** $p < .01$.

Table 6

Mean Predicted TOW Gunnery Score and Pass Rate as a Function of Prediction Model

Sample	Prediction Model	Predicted Gunnery Score	Predicted Pass Rate
Infantrymen currently assigned as TOW Gunners (N=911)	none	609.94	.81
Predictor based assignment from pool of Infantrymen (N=911)	*g*	664.23**	.92**
	Two-Hand Tracking	685.90**	.97**
	g & Two-Hand Tracking	678.80**	.96**

Note. Significance indicates that the predicted mean Gunnery score or pass rate of the group of recruits hypothetically assigned according to predicted Gunnery performance was higher than that predicted for the group of "Infantrymen currently assigned as TOW Gunners." The specific soldiers selected with the three predictor based procedures overlapped to a certain extent with individuals currently assigned as TOW Gunners. Therefore, the statistical test used for this analysis assumed that the groups were dependent and yielded conservative estimates of significance. By definition, for the sample "Infantrymen currently assigned as TOW Gunners," actual and predicted mean gunnery score and pass rate are equal.
** $p < .01$.

Impact of Hypothetical Assignment on TOW Gunner and Remaining Infantrymen Predictor Score Means

Table 7 presents the means on *g* and Two-Hand Tracking for those hypothetically and actually assigned as TOW Gunners and those not so assigned. Assignment based on *g* increased the mean *g* score of those placed as TOW Gunners by 1.76 standard deviations, whereas assignment based on Two-Hand Tracking increased the mean *g* score of those assigned as TOW Gunners by only 0.56 standard deviations. In comparison, assignment based on Two-Hand Tracking increased the mean Two-Hand Tracking score of those placed as TOW Gunners by 1.61 standard deviations, whereas assignment based on *g* increased the mean Two-Hand Tracking score of those placed as TOW Gunners by only 0.58 standard deviations.

A more moderate picture emerges when mean *g* and tracking scores are examined for those not assigned as TOW Gunners. When *g* is used to assign TOW Gunners, the average *g* for those not assigned as TOW Gunners drops 0.16 standard deviations and the tracking scores drop 0.05 standard deviations. Nearly the converse occurs when tracking ability is used for TOW Gunner assignment. This more moderate picture occurs because less than 9% of the Infantrymen were assigned as TOW Gunners.

These outcomes indicated that using Two-Hand Tracking for TOW Gunner assignment, compared to *g*, resulted in better expected Gunnery performance while at the same time better maintaining the distribution of general cognitive ability as gauged by *g*.

DISCUSSION

With respect to the hypotheses, the incremental validity of .05 was not as large as expected, although it was a moderate and statistically significant improvement, and one which substantially improved TOW gunnery performance and the successful completion of training, even as it targeted general cognitive ability to a substantially lesser extent.

The foundational work supporting the basis for the potential value of classification using the tracking test is coming into place. However, one major requirement needed to demonstrate the tracking test's utility in a classification framework still needs to be firmly supported: that there are occupations where performance is unaffected by tracking ability. A case for this can easily be made, for even within the Infantry job cluster it is clear that a Mortarman (i.e., sets coordinates on weapons system, fires the weapon, and does not interact with the weapon further) probably gains little from good tracking ability.

The use of testing for assignment and classification decisions, while commonplace in education (Cronbach and Gleser, 1965), is rarely utilized in organizations. Our results suggest that this may be unwise. The current results indicated that using just a single predictor to hypothetically assign Infantrymen as TOW Gunners can greatly improve the mean predicted TOW simulator gunnery performance. Most importantly, using classification techniques and some

Table 7

Mean Performance of TOW Gunners and Remaining Infantrymen on *g* and Two-Hand Tracking as a Function of Prediction Model

		Hypothetically Placed/Actually Assigned as TOW Gunners		Remaining Infantrymen	
Sample	Prediction Model	*g*	Two-Hand Tracking	*g*	Two-Hand Tracking
All Infantrymen (N=10,852)	none	---	---	66.22	54.41
Infantrymen currently assigned as TOW Gunners (N=911)	none	66.21	54.57	66.22	54.40
Predictor based assignment from pool of Infantrymen (N=911)	*g*	76.32 **	59.44 **	65.29	53.95
	Two-Hand Tracking	69.45 **	68.41 **	65.92	53.13
	g & Two-Hand Tracking	73.64 **	67.02 **	65.54	53.26

Note. Significance denoted by asterisks is for the comparison of means for those "Hypothetically/Actually Assigned as TOW Gunners" with the "Remaining Infantrymen". Significance denoted by the double underline is for the comparison of means across samples "Infantrymen currently assigned as TOW Gunners" with "Predictor based assignment from pool of Infantrymen." The specific soldiers selected with the three predictor based procedures overlapped to a certain extent with individuals currently assigned as TOW Gunners. Therefore, the statistical test used for this analysis assumed that the groups were dependent and yielded conservative estimates of significance.

** $p < .01$. ______ $p < .01$.

constraints (e.g., maintain current cognitive ability distribution across occupations), it may be possible to obtain an increase in TOW gunnery performance with minimal or no loss of gunnery and general occupational performance in other military occupations.

For example, if TOW Gunners were assigned directly from the pool of all applicants, it is likely that their mean tracking ability could be increased 1.76 standard deviations (i.e., the increase in tracking ability observed when the highest tracking ability recruits were assigned as TOW Gunners in the current sample) while constraining average *g* to remain the same for the recruits available for all other Army occupations. A constant average *g* could probably be accomplished given that the applicant population correlation of *g* with Two-Hand Tracking was only .60 and the proportion of TOW Gunner recruits relative to recruits for all Army occupations is small. This would also probably be possible even if all Infantry occupations required tracking ability since Infantry occupations currently account for only 15% of 60,000 yearly recruits (A. Drisko, personal communication, May 17, 1995).

Harvey (1991) points out that the purpose of job clusters is to determine which jobs can be treated interchangeably for a given purpose. If future research indicates that tracking ability is substantially related to gunnery performance only in the TOW Gunner occupation within the Infantry occupation cluster, then it would suggest that perhaps TOW Gunners should not be included in the Infantry cluster for selection and assignment purposes. Clustering of jobs requiring different specialized abilities will reduce the potential utility gain from classification using the specialized predictor. This would not preclude the TOW Gunner occupation from being included in the Infantry job cluster for other purposes such as training and performance appraisal.

Research Limitations

Although these results were highly suggestive of large potential benefits from the use of a tracking test for TOW Gunner assignment decisions, future research must evaluate the impact of actual assignment using this predictor within a classification framework.

In addition, the results of this study assume that simulator performance reflects on-the-job performance. The gains evident in this research may be overly optimistic if differences in simulator performance are not reflected in on-the-job performance. However, there is also reason to believe that the results of this research are conservative. Wartime gunnery performance is likely to be more variable because the targets may be farther away and move faster than the simulated targets, and will be attempting to evade enemy fire. In turn, this increased variability in performance may increase the relationship between tracking ability and gunnery performance.

Future Research

Classification is most efficient when different skills are required for the jobs being filled. Future research should examine the relatedness of tracking ability to performance in other

occupations. If performance in other occupations is substantially related to tracking ability then those occupations should be kept in the same cluster for selection and assignment decisions.

Follow-on work should then focus on the choice of optimal predictors or combinations of predictors in the framework of a full classification model. Performance data should be collected from other occupations, and the effects of using a battery of tests to classify recruits should be examined. A classification algorithm could then be developed which would maximize the simple or weighted sum of performance across a group of occupations. In addition, the algorithm should constrain general cognitive ability to be equal across occupations in order that other aspects of performance untapped by available criterion measures would not be severely affected.

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